

Intel® Centrino® Duo Mobile Technology Performance Brief



<http://www.intel.com/performance>

January 2006

INFORMATION IN THIS DOCUMENT IS PROVIDED IN CONNECTION WITH INTEL® PRODUCTS. NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT. EXCEPT AS PROVIDED IN INTEL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, INTEL ASSUMES NO LIABILITY WHATSOEVER, AND INTEL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY, RELATING TO SALE AND/OR USE OF INTEL® PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. INTEL PRODUCTS ARE NOT INTENDED FOR USE IN MEDICAL, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS.

Intel may make changes to specifications and product descriptions at any time, without notice. All products, dates, and figures specified are preliminary based on current expectations, and are subject to change without notice. Intel, processors, chipsets and boards may contain design defects or errors known as errata, which may cause the product to deviate from published specifications. Current characterized errata are available on request.

Intel, Pentium, Intel Centrino, Intel Core, MMX and Intel SpeedStep are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries.

*Other names and brands may be claimed as the property of others.

Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. For more information on performance tests and on the performance of Intel products, visit www.intel.com/performance/resources/limits.htm.

Executive Summary:

Intel® Centrino® Duo Mobile Technology

On January 5th 2006, Intel Corporation introduced the revolutionary Intel® Centrino® Duo Mobile Technology platform (formerly codenamed “Napa”) enabling a whole new generation of thin and light notebook PCs that are designed to enable outstanding performance and improved battery life over previous generation Intel® Centrino®

Mobile Technology platforms. Intel® Centrino® Duo Mobile Technology laptops mark a dramatic step forward with the following three next generation components working together to deliver outstanding mobile computing capabilities:

- Intel® Core™ Duo Processor
- Mobile Intel® 945 Express Chipset Family
- Intel® PRO/Wireless 3945ABG Network Connection

The Intel® Core™ Duo processor is Intel’s 1st mobile dual-core processor built on Intel’s next generation 65-nanometer process technology. The Intel Core Duo processor delivers low power and efficient breakthrough mobile performance and responsiveness for demanding business users and consumers alike to concurrently execute multiple threads and run multiple intense applications simultaneously. In addition to the new mobile dual-core architecture, the Intel Core Processor includes several innovative features such as a power-optimized 667MHz system bus, 2MB level-2 shared Intel® Smart Cache, enhanced power management and power saving features such as Intel® Dynamic Power Coordination, Enhanced Intel® Deep Sleep with Dynamic Cache Sizing and Enhanced Intel SpeedStep® Technology. The Intel Core Duo processor also features an enhanced data cache pre-fetch logic, deeper write output buffers and Intel® Digital Media Boost, a micro-architectural performance enhancement for multimedia and floating point applications. The Intel Core Duo processor also includes support for Intel® Virtualization Technology which is a set of hardware enhancements to Intel server and client systems that combined with the appropriate software, will enable enhanced virtualization robustness and performance for both enterprise and consumer uses.

The Mobile Intel® 945 Express Chipset Family is the next generation Intel® Hub Architecture for the notebook PCs using Intel® Centrino® Duo Mobile Technology. The Mobile Intel® 945 chipset family offers higher performance for flexible and scalable platforms based on integrated graphics (945GM/GMS) or discrete graphics (945PM). The Mobile Intel® 945GM chipset with Intel Graphics Media Accelerator 950 delivers exceptional improvements in graphics performance over the previous generation chipset, the Intel® 915GM. The Mobile Intel® 945 Express chipset family also supports dual channel DDR2 memory @ 667MHz, which enables system performance gains on applications that benefit from increased memory bandwidth. Graphics intensive applications, gaming applications, and scientific / technical computing applications all benefit from the improvement in peak memory bandwidth. The Mobile Intel® 945 Express Chipset Family also includes support for native HW acceleration for multi-streaming MPEG-2 (SD & HD) video encode/decode that enables simultaneous playback and record and picture in picture and adaptive De-interlacing enables enhanced visual quality of interlaced content on progressive displays. Features such as Intel® Display Power Saving Technology 2.0 and Intel® Dual Frequency Graphics Technology deliver improved power savings.

The Intel® PRO/Wireless 3945ABG Network Connection is advancing WLAN performance of standard Wi-Fi networks, and supports enhanced features that make applications more aware, connected, and responsive, delivering a better on-the-go end-user experience. Available in a smaller PCIe mini-card form factor, the Intel PRO/Wireless 3945ABG Network Connection helps enable lighter and thinner notebooks. With the available Intel®



Intel® Centrino® Duo Mobile Technology Performance Brief

PROSet/Wireless software version 10, enterprise users can take advantage of new IT administration tool capabilities and an API built around 802.11e QoS for VoIP.

Intel® Centrino® Duo Mobile Technology laptops deliver breakthrough mobile capabilities to help businesses respond by:

1. Being more responsive with breakthrough dual-core processing capabilities
2. New innovations for enhanced manageability & better security in today's increasingly mobile business environment
3. Improved battery life to increase mobility and productivity+
4. Extended connectivity options give employees more flexibility to collaborate with clients and colleagues

Intel® Centrino® Duo Mobile Technology laptops enable consumers to enjoy a thrilling and immersive digital entertainment experience by delivering:

1. Revolutionary mobile dual-core design with enhanced high-definition capabilities for an immersive, personalized entertainment experience
2. Improved battery life to increase your on-the-go mobile lifestyle
3. Expanded connectivity options that give you more flexibility to communicate

This performance brief introduces the next generation Intel® Centrino® Duo Mobile Technology laptop, explains the technologies that make it work, examines the purpose and methods behind some industry standard performance benchmarks, and shows how Intel® Centrino® Duo Mobile Technology currently performs on each of the respective benchmarks. When new benchmarks are introduced, this performance brief will be updated as appropriate.

CONTENTS

Executive Summary: Intel® Centrino® Duo Mobile Technology	3
1. Introduction	6
2. The Intel® Core™ Duo Processor	8
3. Intel® Core™ Duo Processor Product Feature Highlights.....	10
4. Mobile Intel® 945 Express Chipset Family Feature Highlights	13
5. Intel® PRO/Wireless 3945ABG Network Connection Product Feature Highlights.....	15
6. Performance Summary	17
7. Summary of Benchmark Results.....	21
8. Mobile Client Capability Briefs	22
Appendix A: Notebook PC Configuration.....	28

Figures

Figure 1. Intel® Centrino® Duo mobile technology Performance on SYSmark* 2004 SE	19
Figure 2. Intel® Centrino® Duo mobile technology performance on PCMark*05 System and CPU test.....	20
Figure 3. Intel® Centrino® Duo mobile technology performance on 3DMark*05 overall and CPU test.....	21
Figure 4. Intel® Centrino® Duo mobile technology performance on SPEC* CPU2000 Rate with 2 copies.....	22
Figure 5. Intel® Centrino® Duo mobile technology performance and power efficiency with music conversion and high definition video playback.....	23
Figure 6. Intel® Centrino® Duo mobile technology performance and power efficiency with DVD creation and high definition playback.....	24
Figure 7. Intel® Centrino® Duo mobile technology performance and power efficiency with DivX* video playback and photo imaging.....	25
Figure 8. Intel® Centrino® Duo Mobile Technology performance and power efficiency with document compression and system protection.....	26
Figure 9. Intel® Centrino® Duo Mobile Technology performance and power efficiency with business application productivity and system protection.....	27
Figure 10. Intel® Centrino® Duo Mobile Technology performance and power efficiency with data analysis and backup.....	28

Tables

Table 1. Performance Data	21
Table 2. Notebook PC Configuration Used for Performance Measurement.....	28

1. Introduction

On January 5th 2006, Intel Corporation introduced the revolutionary Intel® Centrino® Duo Mobile Technology platform (formerly codenamed “Napa”) enabling a whole new generation of thin and light notebook PCs that are designed to enable outstanding performance and improved battery life over previous generation Intel® Centrino® Mobile Technology platforms. Intel® Centrino® Duo Mobile Technology laptops mark a dramatic step forward with the following three next generation components working together to deliver outstanding mobile computing capabilities:

- Intel® Core™ Duo Processor
- Mobile Intel® 945 Express Chipset Family
- Intel® PRO/Wireless 3945ABG Network Connection

The Intel® Core™ Duo processor is Intel’s 1st mobile dual-core processor built on Intel’s next generation 65-nanometer process technology. The Intel® Core™ Duo Processor delivers low power and efficient breakthrough mobile performance and responsiveness for demanding business users and consumers alike to concurrently execute multiple threads and run multiple intense applications simultaneously. In addition to the new mobile dual-core architecture, the Intel® Core™ Processor includes several innovative features such as a power-optimized 667MHz system bus, 2MB level-2 shared Intel® Smart Cache, enhanced power management and power saving features such as Intel® Dynamic Power Coordination, Enhanced Intel® Deeper Sleep with Dynamic Cache Sizing and Enhanced Intel SpeedStep® Technology. The Intel® Core™ Duo processor also features an enhanced data cache pre-fetch logic, deeper write output buffers and Intel® Digital Media Boost, a micro-architectural performance enhancement for multimedia and floating point applications. The Intel® Core™ Duo Processor also includes support for Intel® Virtualization Technology which is a set of hardware enhancements to Intel server and client systems that combined with the appropriate software, will enable enhanced virtualization robustness and performance for both enterprise and consumer uses.

The Mobile Intel® 945 Express Chipset Family is the next generation Intel Hub Architecture for the notebook PCs using Intel® Centrino® Duo Mobile Technology. The Mobile Intel® 945 chipset family offers higher performance for flexible and scalable platforms based on integrated graphics (945GM/GMS) or discrete graphics (945PM). The Mobile Intel® 945GM chipset with Intel Graphics Media Accelerator 950 delivers exceptional improvements in graphics performance over the previous generation chipset, the Intel® 915GM. The Mobile Intel® 945 Express chipset family also supports dual channel DDR2 memory @ 667MHz, which enables system performance gains on applications that benefit from increased memory bandwidth. Graphics intensive applications, gaming applications, and scientific / technical computing applications all benefit from the improvement in peak memory bandwidth. The Mobile Intel® 945 Express Chipset Family also includes support for native HW acceleration for multi-streaming MPEG-2 (SD & HD) video encode/decode that enables simultaneous playback and record and picture in picture and adaptive De-interlacing enables enhanced visual quality of interlaced content on progressive displays. Features such as Intel® Display Power Saving Technology 2.0 and Intel® Dual Frequency Graphics Technology deliver improved power savings.

The Intel® PRO/Wireless 3945ABG Network Connection is advancing WLAN performance of standard Wi-Fi networks, and supports enhanced features that make applications more aware, connected, and responsive, delivering a better on-the-go end-user experience. Available in a smaller PCIe mini-card form factor, the Intel PRO/Wireless 3945ABG Network Connection helps enable lighter and thinner notebooks. With the available Intel®

PROSet/Wireless software version 10, enterprise users can take advantage of new IT administration tool capabilities and an API built around 802.11e QoS for VoIP.

Notebook PC performance does not depend on the microprocessor alone. Hardware and software system components—such as the operating system, the graphics and I/O subsystems, application software, and memory—may significantly affect performance results. For this reason, this Performance Brief illustrates Intel® Centrino® Duo Mobile Technology performance on a consistent notebook PC configuration. Details of the notebook PC configuration used for the performance scores throughout this brief can be found in Appendix A.

2. The Intel® Core™ Duo Processor

The revolutionary Intel® Core™ Duo processor is Intel's 1st mobile dual-core processor and is built on Intel's next generation 65-nanometer process technology. The Intel® Core™ Duo Processor delivers efficient breakthrough mobile performance and low power.

The following list provides some of the key features of the Intel® Core™ Duo Processor T2600, T2500, T2400, T2300, Intel® Core™ Duo Processor Low Voltage L2400, L2300, and Intel® Core™ Duo Processor Ultra Low Voltage U2500:

- First dual-core processor for mobile with two mobile optimized execution cores in a single processor
- Parallel threads executed on separate cores with dedicated CPU resources
- Power optimized for Performance on Demand
- Intel® Core™ Duo Processor leverages Intel® HT™ Technology ecosystem
- Built on Intel's next generation 65-nm strained silicon process technology
- Supports Intel Architecture with Dynamic Execution
- On-die, primary 32-KB instruction cache and 32-KB write-back data cache
- On-die, 2-MB shared level-two Intel® Smart Cache with Advanced Transfer Cache Architecture
- Enhanced Data Cache and Intel® Smart Cache Pre-fetch Logic
- Deeper Write Output Buffer
- Intel® Digital Media Boost with enhanced performance on Streaming SIMD Extensions 2 (SSE2) and Streaming SIMD Extensions 3 (SSE3)
- The Intel® Core™ Duo Processors and Intel® Core™ Duo Processor Low Voltage support a power-optimized 667-MHz FSB
- The Intel® Core™ Duo Processor Ultra Low Voltage processor supports a power-optimized 533-MHz FSB
- Advanced power management features including Intel® Dynamic Power Coordination, and Enhanced Intel SpeedStep® technology
- Enhanced Register Access Manager
- Micro-Ops Fusion
- Advanced Instruction Prediction
- Dedicated Stack Manager
- Intel® Advanced Thermal Manager with Digital Temperature Sensor
- Intel® Core™ Duo Processors are offered in both Micro-FCPGA and Micro-FCBGA packages
- Intel® Core™ Duo Processor Low Voltage and Intel® Core™ Duo Processor Ultra Low Voltage are offered in Micro-FCBGA package
- Execute Disable Bit support for enhanced security
- Intel® Virtualization Technology

- Dynamic Cache Sizing and Enhanced Intel® Deeper Sleep delivering a low voltage sub-state for additional power savings
- Support for Intel® Mobile Voltage Positioning – VI

3. Intel® Core™ Duo Processor Product Feature Highlights

The revolutionary Intel® Core™ Duo processor is Intel's 1st mobile dual-core processor and is built on Intel's next generation 65-nanometer process technology. The Intel® Core™ Duo Processor delivers efficient breakthrough mobile performance and low power. The processor maintains support for MMX™ Technology, Streaming SIMD instructions, and full compatibility with IA-32 software. In addition to the dual-core architecture, The Intel® Core™ Duo Processor includes a number of features including 2MB shared Intel® Smart Cache, Intel® Digital Media Boost, Intel® Dynamic Power Coordination, Intel® Advanced Thermal Manager, Enhanced Intel® Deeper Sleep with Dynamic Cache Sizing, Intel® Virtualization Technology, Enhanced Intel SpeedStep® technology support, a high performance power-optimized system bus with speeds up to 667MHz, and 32KB Level 1 instruction and data caches. These features and resulting benefits are described in more detail below:

- Mobile-optimized Dual-Core Architecture

The Intel® Core™ Duo Processor is Intel's 1st mobile dual-core processor delivering breakthrough power-efficient mobile performance. It includes two mobile-optimized execution cores in a single processor that enable parallel threads or applications to be executed on separate cores with dedicated CPU resources. This delivers outstanding performance and responsiveness to run multiple demanding applications simultaneously and enhanced performance on multi-threaded applications. The Intel® Core™ Duo Processor also features a high performance core architecture that uses techniques like micro-op fusion and Advanced Stack Management to maximize performance. Micro-op fusion combines micro-ops derived from the same macro-op. Advanced Stack Management reduces the number of micro-ops in stack related operations by tracking relative stack pointer changes locally. Reduction in number of micro-ops results in more efficient scheduling and better performance at lower power.

- Intel® Smart Cache

The Intel® Core™ Duo Processor features a shared 2MB level-2 cache with Advanced Transfer Cache Architecture and system bus between the two execution cores delivering a smarter and more efficient cache & bus design to enable enhanced Dual-Core performance & power savings. Intel® Smart Cache enables active execution core to access the full 2MB cache when one other execution core is idle. Dynamic cache allocation across both cores enhances performance and reduces cache under-utilization and misses. Efficient data sharing between both cores minimizes front side bus traffic and reduces cache coherency complexity. The processor's enhanced Data Pre-fetch Logic speculatively fetches data to the L2 cache before cache requests occurs, resulting in reduced bus cycle penalties. The Intel® Core™ Duo processor includes the Data Cache Unit Streamer which enhances the performance of the L2 pre-fetcher by requesting L1 warm-ups earlier. In addition, the Writer Order Buffer depth is enhanced to help with the write-back latency performance. The centralized Intel® Smart Cache control logic enables power optimization and power savings. The Intel® Core™ Duo processor also features on-die, 32-KB level-1 instruction and data caches.

- Intel® Digital Media Boost

The Intel® Core™ Duo Processor features micro-architectural enhancements that include instruction optimizations and performance enhancements for existing Streaming SIMD Extensions 2 (SSE2). In addition to enhancing the performance of existing Streaming SIMD Extensions 2 (SSE2), there are 13 new instructions which further extend the capabilities of Intel processor technology. These new instructions are called Streaming SIMD Extensions 3 (SSE3). 3D graphics and other entertainment applications such as gaming will have the opportunity to take advantage of these new instructions. The Intel® Core™ Duo Processor also features other floating point performance enhancements and a faster integer divide.

- Intel® Dynamic Power Coordination

The Intel® Core™ Duo Processor delivers Dual-Core coordinated performance on demand with enhanced low power management. Intel® Dynamic Power Coordination enables individual cores to dynamically transition to Halt, Stop Clock, and Deep Sleep power management states and also enables dual-core coordinated platform Deeper & Enhanced Deeper Sleep transitions. The shared Power Management Logic coordinates Enhanced Intel SpeedStep® & idle power management state (C-states) transitions in HW to efficiently manage voltage and frequency. The Intel® Core™ Duo Processor can operate at very low voltages and uses advanced techniques to minimize clock and signal switching, resulting in low power dissipation in the active state. The Intel® Core™ Duo Processor features new low frequency mode power management states that allow the processor to quickly enter and exit from these states to provide fast responsiveness and significant power savings. Intel® Core™ Duo Processor also features Dynamic Bus Parking that enables platform power savings by allowing the chipset to power down with the processor in these low-frequency mode states.

- Enhanced Intel® Deeper Sleep with Dynamic Cache Sizing

The Intel® Core™ Duo Processor features a new power savings mechanism that enables the level-2 Intel® Smart Cache to dynamically flush its ways to system memory based on demand or during periods of inactivity. Power savings occur as Cache ways are turned off once the data has been saved in memory. Since L2 Cache data integrity determines Deeper Sleep minimum voltage limit for the processor, once the Dynamic Cache Sizing feature flushes the entire level-2 cache to memory, The Intel® Core™ Duo Processor transitions to a new power management state called Enhanced Intel® Deeper Sleep that allows the processor to lower its voltage below the Deeper Sleep minimum voltage to enable enhanced power savings.

- Intel® Advanced Thermal Manager

The Intel® Core™ Duo Processor features a new thermal management system delivering enhanced accuracy and more precise acoustic control. The Intel® Core™ Duo Processor includes a new digital temperature sensor and thermal monitor on each individual core located close to the hot spots for enhanced accuracy at higher temperatures enabling more precise fan control. The processor also enables support for Intel's next generation dual-core optimized voltage regulator, Intel® Mobile Voltage Positioning (Intel® MVP VI). The Intel® Core™ Duo Processor continues to include the legacy thermal diode in the shared area as a failsafe mechanism.

- Power-Optimized 667MHz System Bus

The Intel® Core™ Duo Processor system bus utilizes a split-transaction, deferred reply protocol. The FSB uses Source-Synchronous Transfer (SST) of address and data to improve performance by transferring data four times per bus clock (4X data transfer rate, as in AGP 4X). The 4X data bus can deliver data four times per bus clock and is referred to as “quad-pumped” or 4X data bus, the address bus can deliver addresses two times per bus clock and is referred to as a “double-clocked” or 2X address bus. Working together, the 4X data bus and the 2X address bus provide a data bus bandwidth of up to 5.33 GB/second. The FSB uses Advanced Gunning Transceiver Logic (AGTL+) signaling technology, a variant of GTL+ signaling technology with low power enhancements.

- Enhanced Intel SpeedStep® Technology Support

The Intel® Core™ Duo Processor features Enhanced Intel SpeedStep® Technology support at multiple voltage and frequency operating points. Highlights of this technology include:

- Multiple performance modes ranging from the Lowest Frequency Mode (LFM) to Highest Frequency Mode (HFM) enable optimum performance at the lowest power
- Real-time dynamic switching of the voltage and frequency between multiple performance modes based on CPU demand. This occurs by switching the bus ratios, core operating voltage, and core processor speeds without resetting the notebook PC
- Software control of voltage and frequency operating points
- Very low transition latency

- 32KB Level 1 Instruction and Data Caches

Both Instruction and Data Caches on the Intel® Core™ Duo Processor are 32KB in size. Large L1 caches provide fast access to critical instructions and data, resulting in very high performance.

- Intel® Virtualization Technology

The Intel® Core™ Duo Processor includes support for Intel® Virtualization Technology which is a set of hardware enhancements to Intel server and client systems that combined with the appropriate software, will enable enhanced virtualization robustness and performance for both enterprise and consumer uses. Intel Virtualization Technology forms the foundation of Intel technologies focused on improved virtualization, safer computing, and system stability. For client systems, Intel Virtualization Technology's hardware-based isolation helps provide the foundation for highly available and more secure client virtualization partitions.

- Advanced Branch Prediction

The Intel® Core™ Duo Processor features an advanced branch prediction architecture that combines three types of predictors – Global, Bi-Modal and Loop Detector. The processor automatically selects the most optimal algorithm to use, significantly reducing the number of mis-predicted branches.

- Execute Disable Bit

The Intel® Core™ Duo Processor supports the Execute Disable Bit capability. This feature combined with a support operating system allows memory to be marked as executable or non executable. If code attempts to run in non-executable memory the processor raises an error to the operating system. This feature can prevent some classes of viruses or worms that exploit buffer overrun vulnerabilities and can thus help improve the overall security of the system. See the *Intel® Architecture Software Developer's Manual* for more detailed information. Please refer to the *Mobile Yonah Processor BIOS Writer's Guide* for BIOS implementation details for Execute Disable Bit support.

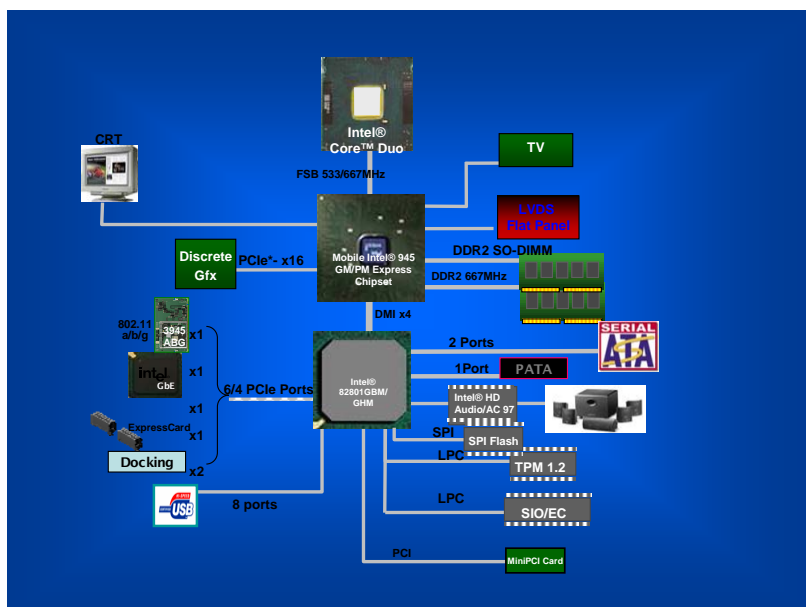
- Micro FCPGA & FCBGA packaging technology

The Intel® Core™ Duo Processor utilizes socketable Micro Flip-Chip Pin Grid Array (Micro-FCPGA) and surface mount Micro Flip-Chip Ball Grid Array (Micro-FCBGA) package technology optimized for a range of thinner, lighter designs including <1" thick that deliver outstanding performance. The Micro-FCPGA package plugs into a 479-hole, surface-mount, Zero Insertion Force (ZIF) socket, which is referred to as the mPGA479M socket.

4. Mobile Intel® 945 Express Chipset Family Feature Highlights

The Mobile Intel® 945 Express Chipset Family is the next generation Intel Hub Architecture for the notebook PCs using Intel® Centrino® Duo Mobile Technology.

The Mobile Intel® 945 chipset family offers higher performance for flexible and scalable platforms based on integrated graphics (945GM/GMS) or discrete graphics (945PM). The Mobile Intel® 945GM chipset with Intel Graphics Media Accelerator 950 delivers exceptional improvements in graphics performance over the previous generation chipset, the Intel® 915GM. The Mobile Intel® 945 Express chipset family also supports dual channel DDR2 memory @ 667MHz, which enables system performance gains on applications that benefit from increased memory bandwidth. Graphics intensive applications, gaming applications, and scientific / technical computing applications all benefit from the improvement in peak memory bandwidth.



In addition to advanced application support, the Mobile Intel® 945GM chipset was designed with the following features to enhance the end-user experience:

- 667 MHz system bus delivers a high bandwidth connection between the Intel Pentium M processor and the platform.
- Native HW acceleration for multi-streaming MPEG-2 (SD & HD) video encode/decode that enables simultaneous playback and record and picture in picture.

- Adaptive De-interlacing enables enhanced visual quality of interlaced content on progressive displays.
- Intel® Dual Frequency Graphics Technology support that allows the chipset to dynamically switch render clock frequency to match graphics workloads delivering enhanced power savings.
- 4GB maximum memory support
- Support for Dual Channel DDR2 400/533/667-MHz Memory Technology with peak bandwidth up to 8.5GB/s, a 60% improvement in peak bandwidth over DDR533
- PCI Express Bus Architecture delivers a 4x increase in discrete graphics bandwidth and a 2x increase in I/O bandwidth
- Intel® High Definition Audio with increased bandwidth that enables 32-bit output and 192-kHz multi-channel audio. Multi-streaming capabilities enable support for separate audio channels with independent audio streams to different devices.
- Integrated high speed USB 2.0 enables up to 15x faster data transfer rate of USB 1.1 and backward compatibility to support for USB 1.1 devices. The Mobile Intel® 945 Express chipset family provides support for 8 USB 2.0 peripherals.
- Direct Media Interface (DMI) with up to 2-GB/sec concurrent bandwidth. DMI provides up to 4x faster I/O bandwidth compared to previous Intel proprietary Hub link I/O interface.
- Integrated low voltage differential signal (LVDS) interface that enables the notebook display panel to connect directly to the chipset and eliminates the need for a video controller hub component. The result is higher integration for savings in mother board space and reduced bill of materials cost for OEMs.
- Dual Independent Display allows viewing two independent video sources when an external monitor or panel is connected to the notebook.
- Intel® Stable Image Technology is a capability built into the chipset and enabled in the BIOS. This silicon technology provides greater IT software image stability by enabling simple chipset hardware changes without triggering the "new hardware found" message—eliminating automatic and unnecessary re-qualification.
- Serial ATA is a storage interface technology that provides up to 150-MB/Sec transfer rate for disk traffic and provides aggressive link power management functionality.
- Intel® Display Power Saving Technology 2.0 (Intel® DPST 2) reduces display backlight power by up to 400-mW with minimal visual impact to the end user (depending on Intel DPST settings and system use).
- DDR2 Memory self-refresh provides chipset and DIMM power savings by putting memory into a reduced power state when display is still active on DDR2 based platforms.
- Integrated TV Out functionality provides the ability to use a TV as an output device for movie playback, digital images, and gaming.
- DirectX® 9 integrated graphics solution for high definition playback and 3D games.
- Support for wide aspect ratio display modes.

5. Intel® PRO/Wireless 3945ABG Network Connection Product Feature Highlights

The Intel PRO/Wireless 3945ABG Network Connection is advancing WLAN performance of standard Wi-Fi networks, and supports enhanced features that make applications more aware, connected, and responsive, delivering a better on-the-go end-user experience. Available in a smaller PCIe mini-card form factor, the Intel PRO/Wireless 3945ABG Network Connection helps enable lighter and thinner notebooks. With the available Intel® PROSet/Wireless software version 10, enterprise users can take advantage of new IT administration tool capabilities and an API built around 802.11e QoS for VoIP.

Advancing WLAN performance and Network Robustness

- Improved performance in noisy environments
- Business Class Wireless Suite, consisting of Optimal AP Selection Technology and Enhanced VoIP Quality Technology
- New API built to take advantage of 802.11e QoS for VoIP

Enhanced Manageability

- Updated IT Administrator Tool providing centralized deployment and control for IT Administrators
- Install package creator to create and distribute profiles, user settings and software updates
- Wake on WLAN

Superior Security

- Cisco Compatible Extensions v4
- Continued support for 802.11i
- Enhanced GUI making it simpler to connect to secure networks.

In addition to the core benefits of Intel® Centrino® Duo Mobile Technology, additional highlights of the Intel® PRO/Wireless 3945ABG Network Connection include:

- Intel Next Generation Silicon Radio and Mac
- Compact packaging with PCIe mini-card single sided PCB (~1/2 size of mPCI)
- New Value Added Features and Functionality
 - VoIP support
 - Intelligent Networking

- Wake on Wireless LAN (WoWLAN)
 - Improved interference immunity
 - More flexible power management
 - Improved Tx/Rx performance
- Key Standards
 - 802.11a/b/g
 - 802.11e EDCA w/ Admission Control (for QoS)
 - 802.11i (security)
- Security
 - WEP (64 & 128 bit)
 - WPA, WPA2 / 802.11i
 - EAP-FAST
- Certifications
 - Wi-Fi, WHQL, WMM, WPA2
 - Cisco Compatible Extensions
- Available Intel® PROSet/Wireless software version 10 enables a superior mobile experience with:
 - Enhanced, even simpler User Interface
 - Added IT Administration Tool capabilities
 - Install package creator
 - Central control over driver & app settings
 - Single Sign On for networks
 - Enhanced VoIP usage model
 - New VoIP API for QoS
 - VoIP profiles and statistic reporting
 - Wide band codec support
 - Additional profile mgmt capabilities
 - OS: Windows XP, Windows 2000, Linux (driver only)

6. Performance Summary

Productivity Performance: SYSmark® 2004 SE

SYSmark® 2004 SE is BAPCo's mainstream office productivity and Internet content creation benchmark tool used to characterize the performance of the business client. It features user-driven workloads and usage models developed by application experts as well as reflects current and emerging computing trends and the recommended benchmark for measuring productivity performance. <http://bapco.com/>

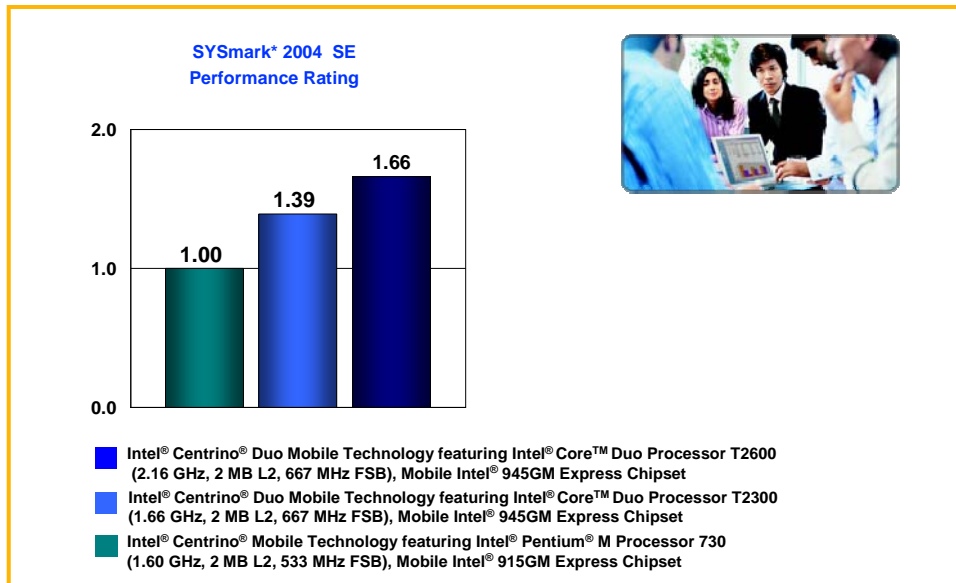


Figure 1. Intel® Centrino® Duo mobile technology Performance on SYSmark® 2004 SE

Consumer Performance: PCMark*05

PCMark*05 test from FutureMark* is a tool for measuring PC performance for home usage. PCMark measures system level performance as well as individual PC component. <http://futuremark.com/products/pcmark05/>

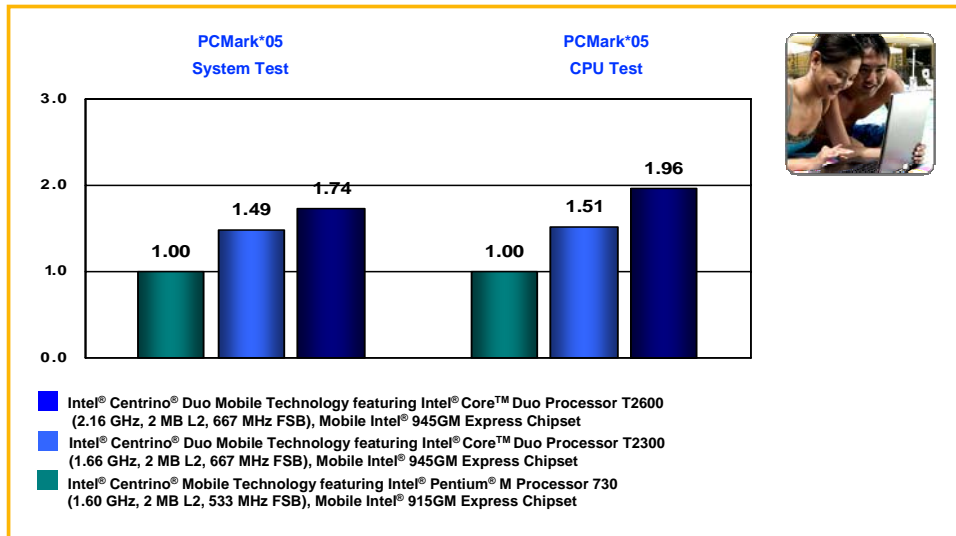


Figure 2. Intel® Centrino® Duo mobile technology performance on PCMark*05 System and CPU test

3D Experience: 3DMark®05

3DMark®05 from FutureMark® is a benchmarking tool that combines the latest DirectX® 9.0 support with unique and updated tests and graphics. The CPU Test measures the contribution of the processor on 3D graphical performance while the Game Test or Overall Test measures game simulation performance.

<http://futuremark.com/products/3dmark05/>

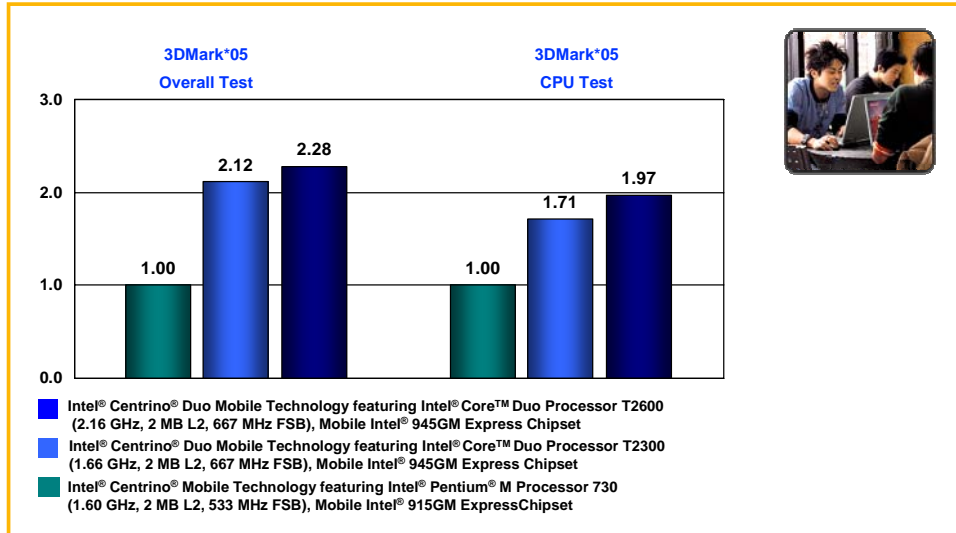


Figure 3. Intel® Centrino® Duo mobile technology performance on 3DMark®05 overall and CPU test

Scientific Experience: SPEC® CPU2000

SPECint_rate_base2000 and SPECfp_rate_base2000 are capacity-based metrics used to measure throughput of a computer that is performing a number of tasks. This is achieved by running multiple copies of each benchmark simultaneously with the number of copies set to the number of logical hardware cores seen by the operating system.

<http://www.spec.org/>

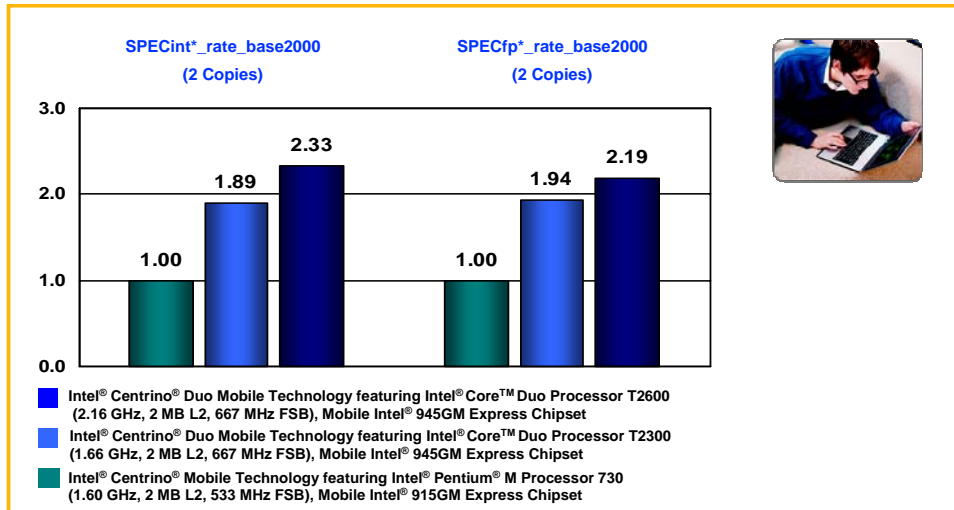


Figure 4. Intel® Centrino® Duo mobile technology performance on SPEC® CPU2000 Rate with 2 copies

7. Summary of Benchmark Results

Table 1 summarizes the benchmark performance of Intel® Centrino® Duo Mobile Technology featuring Intel® Core™ Duo processor T2600 and T2300, Intel® Centrino® Mobile Technology featuring Intel® Pentium® M processor 730.

Benchmarks	Intel® Centrino® Mobile Technology featuring Intel® Pentium® M processor 730	Intel® Centrino® Duo Mobile Technology featuring Intel® Core® Duo processor T2300	Intel® Centrino® Duo Mobile Technology featuring Intel® Core® Duo processor T2600
SYSmark® 2004 SE – Overall Score	139	193	231
PCMark®05 – Overall Score	1691	2517	2938
PCMark®05 – CPU Test	2575	3891	5043
3DMark®05 – Overall Test	248	526	565
3DMark®05 – CPU Test	2130	3646	4202
SPECint*_rate_base2000 (2 Copies)	15	28.3	34.9
SPECfp*_rate_base2000 (2 Copies)	12.5	24.2	27.4

Table 1. Performance Data

Formatted: Bullets and Numbering

8. Mobile Client Capability Briefs

Digital Home: Music Conversion and High Definition Playback

Enjoy high definition video content while your uncompressed audio files are being converted to compressed format for on-the-go listening. Uncompressed audio gives you the highest quality listening experience but is not a convenient format for taking with you on the road. The Intel® Core™ Duo processor has the capability to deliver real time savings and reduced power consumption while you engage in all your favorite digital lifestyles.

iTunes* used to convert a 69.5 minute .wav file with sampling rate of 44.1KHz and sampling size of 16 bits with two channels to .mp3 file format Windows* Media Player* 10 used to playback ## minutes 720P High Definition (HD) Windows Media Video.

iTunes* and Windows* Media Player* 10

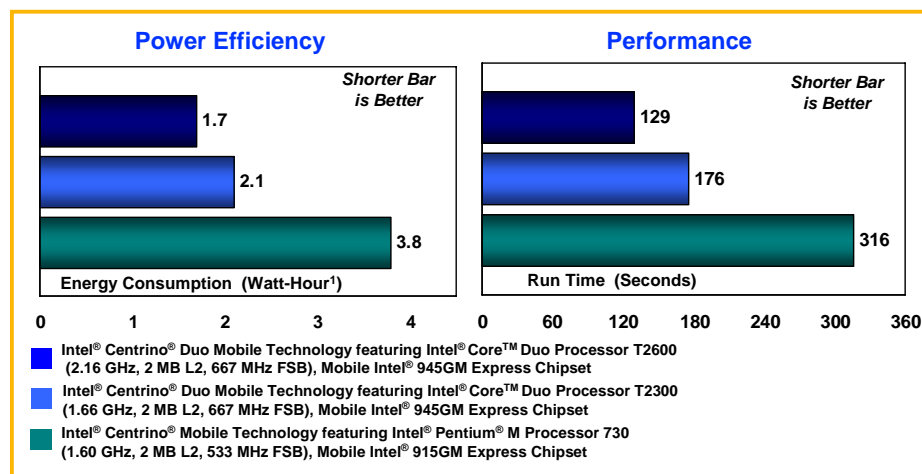


Figure 5. Intel® Centrino® Duo mobile technology performance and power efficiency with music conversion and high definition video playback

Convert uncompressed audio to compressed Format while watching high definition video	Time to Complete (Seconds)	Power Efficiency (Watt-Hour)	Normalized Performance Improvement	Normalized Power Efficiency
Intel® Centrino® Mobile Technology Intel® Pentium® M Processor 730 Mobile Intel® 915GM Express Chipset Intel® PRO/Wireless 2915 ABG Network Connection	316	3.8	1.00	1.00
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2300 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	176	2.1	1.80	1.81
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2600 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	129	1.7	2.45	2.24

Digital Home: DVD Creation and High Definition Playback

Why wait to enjoy high definition video? With Intel® Centrino® Duo mobile technology you can preserve your family's memories on DVD while watching your favorite high definition video. This multitasking scenario shows that the Intel® Core™ Duo processor has the capability to enable brand new usage models for consumers so they can have more fun on-the-go while consuming less energy.

Microsoft® Windows® Media Player 10 used for playback of 30 FPS NTSC, 24 Mbps HD 1080i MPEG2 video.
Pinnacle® Studio® 9 used to prepare 6.2 Mbps Standard Definition (SD) 480i DV NTSC video for burning to DVD.

Microsoft® Windows® Media Player® 10 and Pinnacle® Studio® 9b

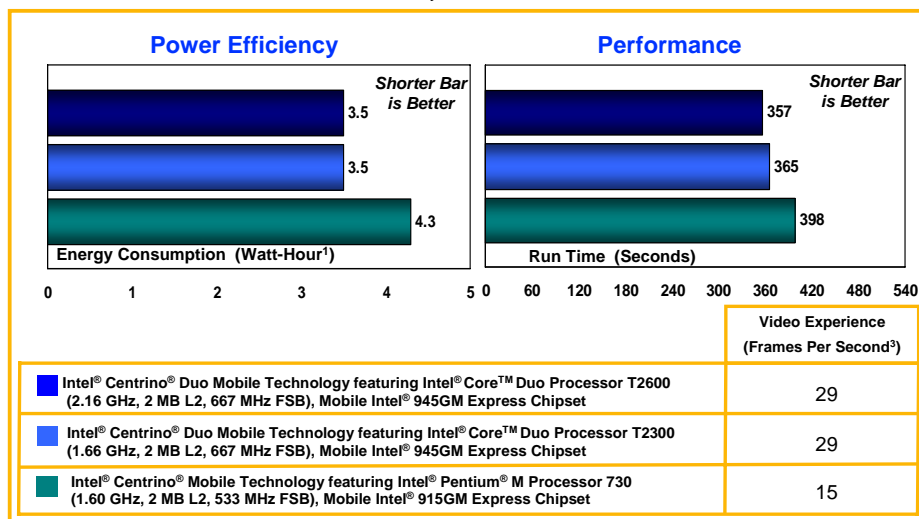


Figure 6. Intel® Centrino® Duo mobile technology performance and power efficiency with DVD creation and high definition playback

Create DVD image while watching high definition video	Time to Complete (Seconds)	Power Efficiency (Watt-Hour)	Normalized Performance Improvement	Normalized Power Efficiency
Intel® Centrino® Mobile Technology Intel® Pentium® M Processor 730 Mobile Intel® 915GM Express Chipset Intel® PRO/Wireless 2915 ABG Network Connection	398	4.3	1.00	1.00
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2300 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	365	3.5	1.09	1.23
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2600 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	357	3.5	1.11	1.23

Digital Home: DivX® Video and Photo Imaging

Enjoy high quality downloaded DivX® video content from the web while simultaneously fixing and enhancing your latest vacation photographs. The Intel® Core™ Duo processor provides breakthrough power efficient performance and brings new possibilities to the way you enjoy your music, videos, and photos on-the-go.

Microsoft® Windows® Media Player 10 used for playback of 2:13 DivX® video clip downloaded from the web, Adobe® Photoshop® Elements 4.0 used to fix and enhance group of sixty (3 mega pixel) photographs.

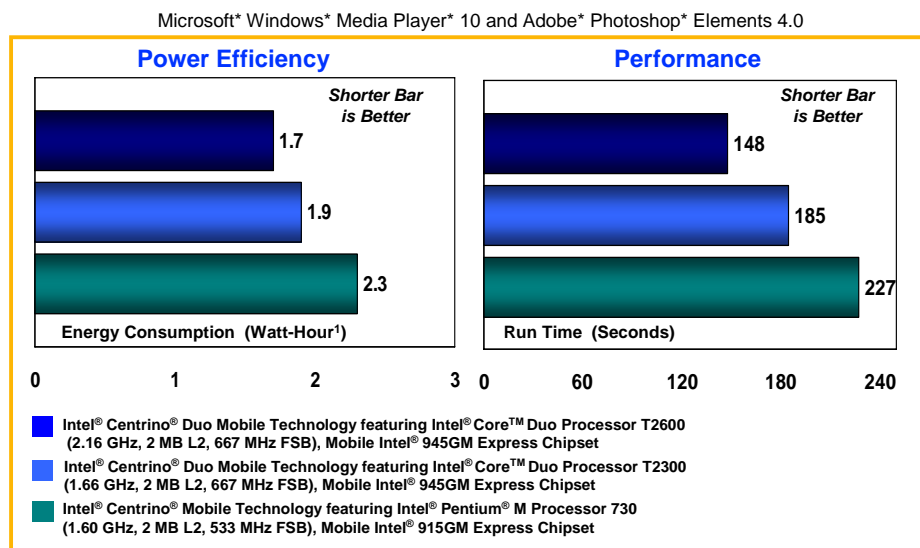


Figure 7. Intel® Centrino® Duo mobile technology performance and power efficiency with DivX® video playback and photo imaging

Watch DivX® video while enhancing digital photographs	Time to Complete (Seconds)	Power Efficiency (Watt-Hour)	Normalized Performance Improvement	Normalized Power Efficiency
Intel® Centrino® Mobile Technology Intel® Pentium® M Processor 730 Mobile Intel® 915GM Express Chipset Intel® PRO/Wireless 2915 ABG Network Connection	227	2.3	1.00	1.00
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2300 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	185	1.9	1.23	1.21
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2600 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	148	1.7	1.53	1.35

Digital Office: Document Management and System Protection

Convert your large presentations into compressed format for easy and portable distribution while your system transparently protects itself from harmful viruses. With the power efficient Intel® Core™ Duo Processor you can complete your processor intense business tasks while your system seamlessly manages it's background maintenance functions.

Adobe® Acrobat® used to convert a 152 PowerPoint® slide presentation to PDF format. McAfee® VirusScan® used for checking viruses on approximately 1.2GB of files.

Adobe® Acrobat®, Microsoft® PowerPoint®, and McAfee VirusScan®

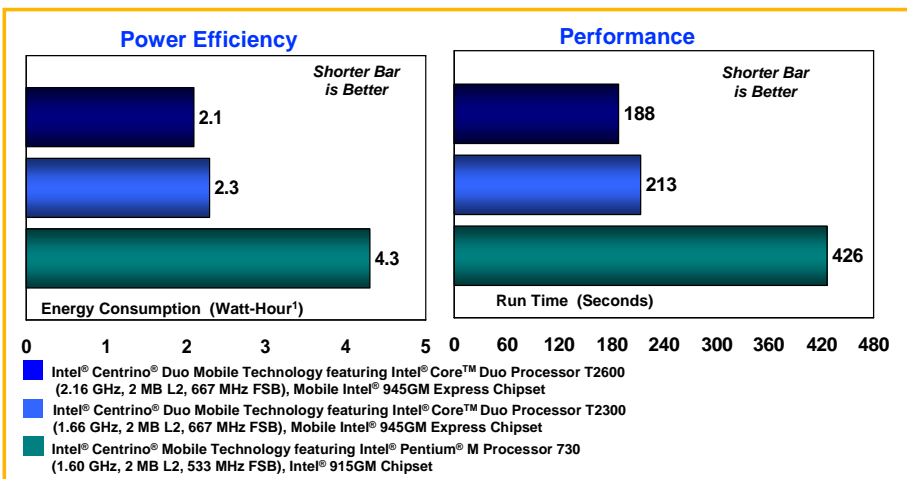


Figure 8. Intel® Centrino® Duo Mobile Technology performance and power efficiency with document compression and system protection

Document compression and virus scanning	Time to Complete (Seconds)	Power Efficiency (Watt-Hour)	Normalized Performance Improvement	Normalized Power Efficiency
Intel® Centrino® Mobile Technology Intel® Pentium® M Processor 730 Mobile Intel® 915GM Express Chipset Intel® PRO/Wireless 2915 ABG Network Connection	426	4.3	1.00	1.00
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2300 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	213	2.3	2.00	1.87
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2600 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	188	2.1	2.27	2.05

Digital Office: Multitasking and Responsiveness

Experience amazing responsiveness when running multiple applications at once.. With the breakthrough performance of the Intel® Core™ Duo Processor you have the power to archive email messages, view PowerPoint® presentations, and run Excel® calculations simultaneously. With power optimized Intel® Centrino® Duo mobile technology you can concentrate on your business tasks without the need to manage your own system resources for better responsiveness.

Microsoft® Outlook®, PowerPoint®, and Excel® are the office applications used in this scenario. McAfee® VirusScan® used to scan 1.4GB of files.

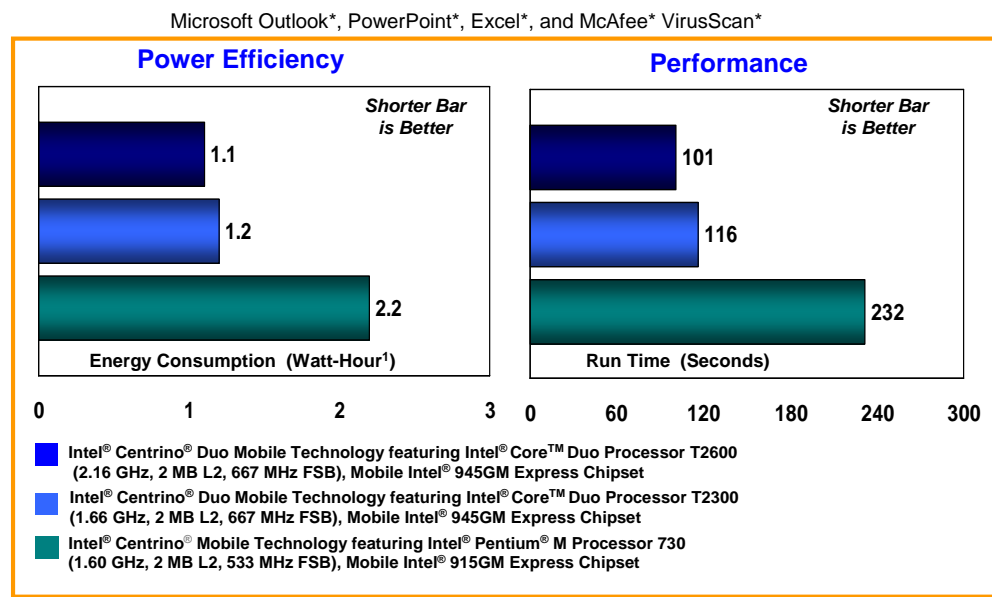


Figure 9. Intel® Centrino® Duo Mobile Technology performance and power efficiency with business application productivity and system protection

Multitasking with office applications while scanning for viruses	Time to Complete (Seconds)	Power Efficiency (Watt-Hour)	Normalized Performance Improvement	Normalized Power Efficiency
Intel® Centrino® Mobile Technology Intel® Pentium® M Processor 730 Mobile Intel® 915GM Express Chipset Intel® PRO/Wireless 2915 ABG Network Connection	232	2.2	1.00	1.00
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2300 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	116	1.2	2.00	1.83
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2600 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	101	1.1	2.30	2.00

Digital Office: Data Analysis and Backup

Help your business respond: Imagine you're compressing, encrypting, and backing up your critical business data when your boss needs you to generate financial information right now. With Intel® Centrino® Duo mobile technology you have the power to perform processor intense statistical analysis without having to wait for background maintenance tasks to complete.

Decisioneering® Crystal Ball® 9 used to perform statistical analysis on Excel® data utilizing a Monte Carlo simulation. A Monte Carlo simulation randomly generates values for uncertain variables over and over to simulate a model. EMC2 Dantz Retrospect® 7 used to encrypt, compress, and backup 450 MB of Microsoft® Word® documents and Adobe® Acrobat® files.

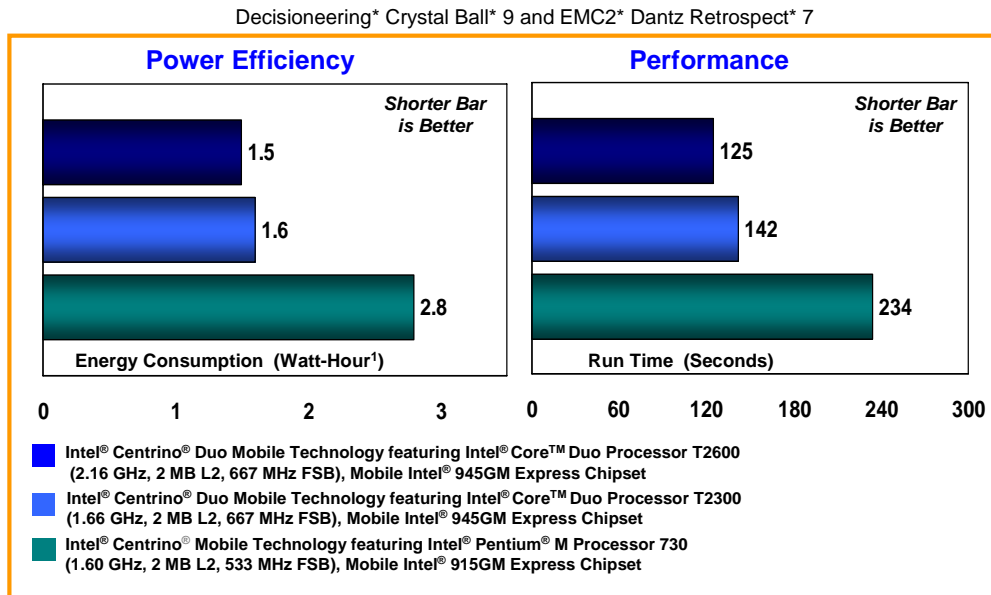


Figure 10. Intel® Centrino® Duo Mobile Technology performance and power efficiency with data analysis and backup

Perform statistical analysis while compressing, encrypting and backing up data	Time to Complete (Seconds)	Power Efficiency (Watt-Hour)	Normalized Performance Improvement	Normalized Power Efficiency
Intel® Centrino® Mobile Technology Intel® Pentium® M Processor 730 Mobile Intel® 915GM Express Chipset Intel® PRO/Wireless 2915 ABG Network Connection	234	2.8	1.00	1.00
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2300 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	142	1.6	1.65	1.75
Intel® Centrino® Duo Mobile Technology Intel® Core™ Duo Processor T2600 Mobile Intel® 945GM Express Chipset Intel® PRO/Wireless 3945 ABG Network Connection	125	1.5	1.87	1.87

¹ Measured in watt-hours. The watt-hour (symbolized Wh) is a unit of energy equivalent to one watt of power expended for one hour of time.

Appendix A: Notebook PC Configuration

Table 2. Notebook PC Configuration Used for Performance Measurement

Intel® Mobile System	Intel® Centrino® and Centrino® Duo Mobile Technology		
Processor Name	Intel® Pentium® M processor 730	Intel® Core™ Duo processor T2300	Intel® Core™ Duo processor T2600
Processor Speed	1.60 GHz	1.60 GHz	2.16 GHz
Front Side Bus	533 MHz	667 MHz	
Processor Secondary Cache	2MB Full-Speed On-Die Level 2 Cache	2MB Power Optimized L2 cache with Intel® Smart Cache design	
Motherboard Chipset	Mobile Intel® 915GM	Mobile Intel® 945GM	
Wireless Network Card	Intel® Pro/Wireless LAN 2915ABG	Intel® Pro/Wireless LAN 3945ABG	
Vendor and Model	Lenovo* T43	Lenovo* T60	
Motherboard BIOS	Lenovo* 70ET61WW	Lenovo V .79ET48WW	
Memory Size	Samsung* M470T6554CZ3-CD5 0543 PC2-4200 DDR2-533 SDRAM 4-4-4-12 1024MB (2x512MB)	Elpida* PC4200 DDR2 533 Dual Channel 4-4-4-12 1024MB (2x512MB)	
Chipset INF File	Windows XP*: Intel INF 6.1.0	Windows XP*: Intel INF 7.1.0	
Hard Disk (Used for Industry benchmarks SYSmark 2004, PCMar05, 3DMark05, and SPEC* CPU200)	Fujitsu* HTS726060M9AT00 60GB 7200rpm (Lenovo* Part #13N6807)	Seagate ST910021AS SATA 100GB 7200rpm	
Hard Disk (Used for application-based workloads)	TravelStar* HTS726060M9AT00 60GB 8MB buffer size 5400rpm	Hitachi HTS541080G9SA00 SATA 80GB 5400rpm	
DirectX* Version	DirectX* 9.0c		
Video Controller	Intel® Graphics Media Accelerator (GMA) 900	Intel® Graphics Media Accelerator (GMA) 950	
Video Memory Size/Type	128MB Dynamic Video Memory Technology	128MB Dynamic Video Memory Technology	

Intel® Mobile System	Intel® Centrino® and Centrino® Duo Mobile Technology	
Video Driver Revision used for standard benchmark	6.14.10.3889	6.14.10.4382
Video Driver Revision used for application-based workload	6.14.10.3889	6.14.10.4436
Operating System	Microsoft Windows XP® Professional, Build 2600, Service Pack 2 on NTFS	
Graphics	1024x768 resolution, 32-bit color XGA	
Sound Card	SoundMax Digital Audio	SoundMAX HD Audio
Network Card	Integrated Broadcom® NetXtreme® Gigabit Ethernet	Intel® PRO/1000 PL
Battery Capacity	52 Wh	56Wh
Weight	5.25 lbs	5.25 lbs
Screen Size	14"	
Power Management Mode for all the benchmarks and Software-based workloads	Always On	

¹ Measured in watt-hours. The watt-hour (symbolized Wh) is a unit of energy equivalent to one watt of power expended for one hour of time.